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ABSTRACT

Two myths about high technology are that it will be the primary source of new jobs and that it will vastly upgrade the skill requirements of jobs. Evidence does not support these myths. Most new jobs will not be in high tech fields, and technology will reduce the skill requirements. The Bureau of Labor Statistics predicts that high tech occupations will grow rapidly until 1990, but the actual numbers of jobs that will be created are quite small in comparison to other occupational categories. Technology is shaping the future economy by other forces. Robotics, automation, sophistication of some technologies, and movement of jobs overseas will result in job loss. New jobs will be created by technology in production and maintenance of robots. Skill requirments will also be affected. Reduced skills will be needed to use word processing equipment, computers, and cash registers. Educational implications from these changes include the need to increase and strengthen basic education; the need to strengthen the idea of lifelong, recurrent education; and the need to gear training and education toward adaptability and flexibility. Questions and answers about high technology, vocational education, and changes in the nature of work conclude the document. (YLB)

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Occasional Paper No. 97

DEMYSTIFYING HIGH TECHNOLOGY

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FOREWORD

Since the early 1970s, America has been transformed by new advances in technology, both at home and in the workplace. A recent GAO study has warned that the new wave of automation and high technology has caused the displacement of thousands of workers from their jobs, is changing the nature of the workplace, and is simultaneously creating new occupations. Policies involving vocational education will have to take these facts into consideration if students and workers are to be aptly trained for the evolving work world. Dr. Rumberger's paper entitled "Demystifying High Technology," was presented to the staff of the National Center on August 19, 1983. In this paper he examines the impact of high technology on the workplace, on our nation's ability to generate jobs and increase productivity, and on the relationship between education and the world of work.

Dr. Rumberger is a Senior Research Associate for the Institute for Research on Educational Finance and Governance at Stanford University. He received his B.S. in electrical engineering and computer systems from Carnegie-Mellon University, his M.A. in economics from Stanford University, and his Ph.D. in educational administration and policy analysis from Stanford.

Dr. Rumberger was formerly with the Center for Human Resources Research at The Ohio State University and with the Center for Economic Studies at Palo Alto, California. He is known as an international consultant and has published a number of monographs, articles, and books. His latest book, *A New Social Contract*, was coauthored with Martin Carnoy and Derek Shearer and has been published by Harper and Row.

The National Center and the Ohio State University are pleased to present Dr. Rumberger's expert insights and comments on "Demystifying High Technology." A videotape of the seminar is also available from the National Center.

Robert E. Taylor
Executive Director
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DEMYSTIFYING HIGH TECHNOLOGY

Interest in high technology is widespread around the United States, among people in policy arenas, education, business, and everywhere. We all realize that high technology is going to be an important force in our future lives, and that it may already be. There is much interest in high technology, but there are also many myths about it.

The myths about high technology are twofold. One says that high technology—or "high tech," as it is called—will be the primary source of new jobs in our economy in the coming decades. The second myth is that high technology will vastly upgrade the skill requirements of jobs as people begin working with these new technologies; therefore we are going to have to increase the amount of education and training to enable workers to deal with high technology on the job.

But the evidence does not support these myths. Most new jobs will *not* be in high-tech fields in the future economy, and technology will not require a vast upgrading of workers' skills, because the primary impact of technology will be to *reduce* the skill requirements of jobs.

What evidence supports these surprising conclusions? What trends are already visible and suggest the evolving impacts of technology? One area of confusion that seems to pervade this issue is whether high tech relates to occupations or to industries. High-tech occupations refer to jobs that deal primarily with advanced types of technology, such as engineers, computer specialists, scientists, and related technical support positions. High-technology industries are those that are commonly identified as manufacturers of high-tech products, such as computers, microelectronic products, and similar kinds of technical products.

This kind of confusion is understandable, but the real focus when we talk about high tech should be on occupations, and not on industries. First of all, industries engaged in high-technology production are not significant employers in the United States and will not be in the future. All the different estimates about the size of high-tech industries, depending on whether you define them narrowly or broadly, show that high-tech industries employ no more than 4 to 8 percent of the current American work force. Even in California, the home of Silicon Valley, employment in high-tech industries is less than 10 percent of the work force. In fact, one estimate by the U.S. Bureau of Labor Statistics (1982) shows that the proportion of people working in high-tech industries will be about the same in 1990 as it was in 1980.

A second reason not to focus our main attention on high-tech industries is that much employment in high-tech industries is not high tech; that is, much of the employment in high-tech industries does not involve jobs in high-level research and development, but rather in assembly and other kinds of production jobs. In fact, only about 20 percent of those jobs are in high-tech occupations or high-level occupations; the rest are in relatively low-level assembly and production occupations and associated clerical positions.

The important focus in high technology should be on occupations. The primary source of information on the effects of high technology on occupations is the national employment projections generated by the U.S. Bureau of Labor Statistics (BLS). The BLS has been making

projections about national employment growth for a number of years and its projections are probably the best source of information about what the future job market is going to look like in the United States. Critics have attacked the projections and, of course, they are not above criticism, but compared to other sources of projections they are probably as rigorous and as accurate as any other. They provide a good basis for judging what the future job market will look like.

What do the BLS figures tell us? One prediction is that high-tech occupations, or at least occupations related to technology in some direct fashion, are expected to grow rapidly until 1990. New figures were published in the fall of 1983, but earlier projections are consistent with these. The projections suggest that between 1978-1990 there will be very high growth rates in such high-technology occupations as computer technicians (expected to grow by 148 percent), computer systems analysts (expected to grow by 108 percent), and computer operators (expected to grow by 88 percent). So it is true that some high-tech occupations or technically related occupations will grow at a faster rate than overall employment in the American economy in this period.

The actual numbers of jobs that will be created by these occupations, however, are quite small in comparison to other occupational categories. For example, jobs for computer technicians will grow by 148 percent—and that is expected to be the fastest-growing occupation in the economy over the rest of the decade—but it will create only ninety-three thousand new positions in the economy. The fastest growing occupation in terms of the number of new jobs created will be for janitors, and that will create around six hundred seventy-two thousand new jobs in the economy. Another fast-growing occupation is cashier, which will produce five hundred forty-five thousand new jobs. There will be five hundred thirty-two thousand new jobs for waiters and waitresses.

Clearly, comparisons between high-tech occupations and what are considered service and relatively low-skilled occupations are quite sharp. For every new job for a computer systems analyst, there will be three new jobs for janitors. For every new job for a computer programmer, there will be six new jobs for fast-food workers and kitchen helpers. In fact, if you look at overall employment growth in the area of professional/technical employment, which includes all professional and technical fields, that segment of the job market is likely to grow more slowly in the 1980s than it did in either the 1960s or the 1970s.

These numbers portray quite a different story about high technology and its position in our economy. They predict that technology will not be such an important source of jobs in the future. But underlying these figures are a number of other forces by which technology is shaping the future economy. First, we know that technology eliminates jobs and that it also creates jobs. Second, high technology is likely to have an impact on almost every existing kind of job in the economy, and particularly on the skill requirements of jobs.

The issue of job creation and job loss is widely discussed, but it is difficult to quantify that relationship and develop a credible estimate of what the net impact will be. Technical forces have been shaping the job market for a long time. This is nothing new. What is important is determining whether this impact will be any different today than it has been in the past, and what the magnitude of that impact is likely to be.

A number of studies have tried to answer these questions for specific kinds of technologies, and they do suggest a direction. One example is in the area of robotics, a type of technology that has received widespread publicity. It is a state-of-the-art technology that is only just evolving, and it receives much of the limelight because the Japanese use a lot more robots than

we do. Also, certain kinds of American industries, automobile manufacturing being perhaps the best example, are moving toward utilizing more robots. Studies by Carnegie-Mellon University's Robotics Institute suggest that robots have the potential to displace up to 3 million jobs in the next twenty years, and could eliminate all 8 million operative jobs by the year 2025. The potential for technology to eliminate jobs or displace workers is quite great, and robots are just one example. These numbers become even more significant if you think about the size of today's work force.

There are other areas where new technology may result in job loss. For example, two of the largest banks in California have just announced that, over the next few years, they will close a total of seventy-one branch offices, replacing them with automatic teller machines that will be located in very convenient places. The new teller machines will handle many banking transactions, though there will always be a need for human tellers and human jnteraction for certain kinds of banking operations. But the new automatic teller machines will perform a number of transactions that formerly had to be handled by human tellers. And the way to the future in banking, of course, is to use these little home-based terminals, which will also allow you to do shopping and all kinds of other things. That is just one example of a type of technology that could, in fact, displace jobs.

This displacement will not simply occur in low-level, mundane areas in the economy; that is, it will not merely displace the most undesirable jobs in the economy, which is a common notion. Sophistication in some technologies will also enable job displacement to occur at relatively high levels in the economy. In fact, the incentive for employers to substitute high-technology machines or systems for human workers is really associated with jobs that pay much higher wages than with the low-skill jobs that pay low wages. Robots are being used to displace autoworkers who earn ten or twelve dollars an hour. Robots will not—at least in the first round—displace people who earn the minimum wage. So job displacement is going to occur not just at the bottom of the economy, but even more so in the middle and possibly even th e upper-middle range. In the latter case, for example, drafters' jobs are threatened by the use of computer-aided design (CAD). It may not be too long before there are no more drafting positions, because engineers can do the designing on the machine, which will produce the prints and modifications to the prints both cheaply and quickly.

Another kind of job loss, perhaps due less directly to technology but equally important, is the movement of jobs overseas. We have seen evidence of this in the past, and are likely to see more of it in the future. The best recent example of this phenomenon is the announcement in 1983 by the Atari Corporation that it would lay off seventeen hundred workers in Silicon Valley next spring and move its production facilities to Taiwan and Hong Kong.

Technology plays a role here because technology facilitates the movement of jobs overseas in a number of ways. First of all, advances in communications and transportation simplify such movement and lower the costs of communicating with the home base, supplying materials, shipping products, and so forth. Technology also allows production to become more automated, so that American companies can conduct even relatively sophisticated production overseas. The companies then use laborers from the third-world countries who have four or five years of schooling and pay them under a dollar an hour. In that way, technology allows the production of fairly sophisticated components and other kinds of devices to be done by relatively low-skilled, low-paid labor.

On the other side of the coin, technology is also creating jobs, not merely destroying them. In fact, jobs have been destroyed in the past in similar ways. But new jobs are created by high tech. For example, in robotics, there will be new jobs for people in the production, maintenance,

and sale of robots. For any kind of new devices, there will need to be workers to manufacture and use them, and there will be growth and employment in those industries.

The real question—one for which there is no ready answer and for which there may never be an answer—is what the net impact of these technological changes is going to be. Will technology produce more jobs than it destroys, or vice versa?

There is some evidence, in the case of robotics, that more jobs will be destroyed than are created. A very current book on robots published by the W.E. Upjohn Institute for Employment Research (Hunt and Hunt 1983) estimates that three jobs will be destroyed for every one job created in the robotics field in the future economy. If that trend carries over into other high-technology areas, the net result will be a loss of jobs in the American labor market. That in itself is a grave social issue, particularly in a time when unemployment in this country is very high and the prospects for lowering unemployment in the near future appear small.

An important concern must be where this job displacement is going to take place. If we think of jobs as being arrayed along a distribution, we will see much more displacement taking place in the middle. So we may be moving to a kind of bipolar distribution of jobs in our economy, which will mean a bipolar distribution of income, benefits, and other aspects of work. There are very grave social implications regarding the distribution of income, and the "haves" and the "have-nots" may have to be defined in a different way in the future. Who will be the people who have the very interesting jobs? Who will have very low-level, low-skill, low-wage jobs? Who will end up being the unemployed? What about other people who are just forced out of the job market? The social issues ultimately revolve around whether we will have enough jobs in our future economy, how people will be allocated to the jobs that exist, and whether serious long-term unemployment will be a major outcome. Income policy issues will also have to be resolved. The point is simply that the effect of technology extends far beyond what the job market will look like in the future.

Another way that technology is shaping the job market in a more profound and widespread manner is how technology is shaping the skill levels of all jobs in the economy. Not only can it destroy and create jobs, but it also affects the skill requirements of almost every job, current and future.

The most direct evidence is in the proliferation of microcomputers. More and more people are using the microcomputer, not only in their homes, but also at work. Whether they use it for word processing, financial analysis, record keeping, or in production, microcomputer technology can be applied in almost any kind of job setting.

This is a very different kind of impact than what has been experienced with other technologies in the past. Before, technologies were applied in specific areas. For example, the automation that took place in production facilities in the 1950s was really concentrated in production types of jobs. It tended to have an impact on certain industries and not affect others. But many current and emerging technologies will probably affect virtually every job sector of the economy, and the impact on skills will be critical.

What, then, will be the impact of high technology on skill requirements? Will it raise or lower skills? The general opinion seems to be that the use of high technology in jobs will raise skill requirements, because the technology itself is more sophisticated; people draw an analogy between sophisticated technologies and sophisticated skill requirements in jobs.

Unfortunately, this is probably not an accurate comparison to make. One of the more thorough examinations of this issue was made by Professor James Bright (1958) at Harvard in the late 1950s. That was a time of widespread automation, as well as of widespread concern about the impacts of automation. Bright studied the application of automation and production processes in a variety of manufacturing industries in the United States. He concluded that the initial impact of the application of technology was to raise the skill requirements of workers using that technology. So there was a certain amount of initial learning that had to be done. But over time, as the technology advanced, the skill requirements declined. A number of other case studies (Zimbalist 1979) support that observation about the effects of technology on some job skills.

The impact of new technologies is probably going to be much the same. A good example is in word processing and office work. More and more people use word processing equipment. First, what this technology does is allow people with very little skill in using computers to use them for word processing. Second, it does away with some of the skills that people have traditionally needed to do office work. Two examples are spelling and letter-perfect typing skills. Now workers do not have to know how to spell, because the computer's software identifies misspelled words, and either corrects them or asks the worker whether they need to be corrected. Secretaries do not need letter-perfect typing skills anymore, because they can just type it on the screen and do all the corrections before they actually print out the perfect letter. So word processing software has greatly reduced the skills needed to use the machines, even though the secretaries are using quite a sophisticated technology.

Computer programming itself is another interesting example of technology's effect on skills. In the 1950s, when computers were first being used commercially, and even in the late 1960s, the languages used to program computers were complex and difficult to learn. They included machine-level languages and difficult scientific languages, such as Algol and Fortran. But now most software in the computer field has evolved to make it easier for people to program with little or relatively little computer experience. This is what the industry calls user-friendly software. The software is fairly simple to use and the computer can even prompt you or ask you a series of questions. The languages have become more English-like—"unformatted," as they say—so that the programmer does not have to worry about putting information in particular columns or using certain kinds of commands to translate it. And the trend in using computers is heading toward voice recognition, so that a computer user will not even have to know how to use a keyboard typing skill because the computer will understand and accept voice commands.

Another occupational area where skills will be affected will be cashiers. Now almost every cash register does all the computation in deciding how much change to give the customer. At McDonald's, for example, a cashier does not punch any numbers; instead, the cashier enters two Big Mac's and three large cokes and the machine automatically tallies the prices of the items and the total bill, including the tax. Then the operator only needs to enter the denomination of the bill with which the customer pays, and the cash register figures the change. So many cashiers no longer need any computational skills, because those skills are now incorporated into the technology of the machine.

One of the most interesting examples, one that may be widespread in the future, is in the area of diagnostics. Automobile diagnostics already use computers in preprogrammed devices to help troubleshoot certain kinds of problems. Auto mechanics use computerized diagnostic equipment in all kinds of maintenance work now. And self-diagnosing features built into automobiles have come a long way. Now sensors all over the automobiles can basically troubleshoot problems or even pinpoint potential problems. So drivers can maintain their own cars, to a certain point. Mechanics can troubleshoot problems more effectively.

These illustrations point up the fact that technology is relatively widespread, and its impact on jobs and job skills is also going to be widespread. In general, that impact is probably going to lower skill requirements. The impacts of new technologies today are different from those in the past, mainly in that the applications are more wid spread than they have ever been before.

Perhaps the most alarming effect is that, whereas past technology tended to displace physical labor in agriculture and manufacturing, the present and future technologies have the potential of displacing mental labor. The effect could be quite profound. More and more analytical and decision-making tasks in jobs can be incorporated into the technologies themselves, thereby reducing the need for those kinds of activities in the workers themselves.

What will these changes mean for education? Any implications we draw at this point are necessarily tentative, because evidence is sparse and many studies are still being done. But one probable implication is simply that, because the impact of technology will be quite diverse, no general, simple educational prescription will emerge from the tendencies or trends. Technology will probably create a demand for more workers than we have now in certain high-tech fields, such as in engineering and computer-related fields. Though the demand will not create many new jobs in the economy, those that are will come about at a faster rate than other jobs. There will always be a need for high-skilled, high-level workers in our future economy. At the same time, there will probably be an increase in low-skilled jobs. So there are no simple statements about what the educational implications are.

Another implication that emerges is a need to increase and strengthen basic education. Jobs are going to change in the future in ways that cannot be anticipated now. But we can expect the impact of technology to be widespread and the rate at which technology changes to increase. We cannot at this point anticipate some of the new technologies that will evolve, nor can we guess what the impact of those technologies will be on jobs and skill requirements.

In addition, people will probably change jobs more often in the future than they have in the past. Part of this will be for personal reasons; evidence shows that people are doing this more now. And of course some people are forced into job or career changes because, as the economy is restructured, some industries decline. So people will work in a wider variety of jobs than they do now.

This points to an increased need for basic education and basic skills, and it goes beyond the simple notion of merely increasing math and science skills. There is much interest in increasing science skills and science requirements in schools today, but it may be every bit as important to increase workers' and students' communicative skills, analytical skills, and technological literacy. Even if people will not have to have a personal knowledge of specific technologies, they should have knowledge about technology, because technology will influence all their lives in the future. They should have an understanding of the nature of technology, and what the forces are that shape technology, so that they, as workers and voters, can make informed decisions in the workplace and in the political arena about how technology may evolve or be applied. In addition, at least in the areas where technology is going to reduce skill requirements, the specific, narrow technical skills will be more easily acquired on the job than in the schools.

A third implication for education is the need to strengthen the idea of lifelong, recurrent education, or education and training. Because people will change jobs more often and the jobs themselves will change, people will be required to learn new skills throughout their working lives. The old notion that people go to school, get training for a specific career, enter that career, and stay with that career throughout their lives is no longer a good model for workers. People are going to have to go back to school or acquire additional training as their jobs change and as

they change jobs. So there must be greater consciousness of the need for adult education or recurrent education.

This idea is strongly related to delivering a good basic education to young people. They need to realize that they will acquire some vocational skills when they first enter the labor market, but that throughout their working lives they will also have to acquire new vocational skills as the need arises. Even if technology does not increase the level of skills, it will probably alter the types of skills that people will need. These skills may, in fact, be easier to learn, but they will be different just the same. There always is going to be a need for acquiring new job-specific skills.

Where does vocational education fit into this scheme? Vocational training or job training will perhaps become more important in the future than it is now because more people will need to be retrained or need to upgrade their skills more often. Vocational education may not need to be strengthened for young people; in fact its importance for them may be diminished because of the need to strengthen basic education. But vocational education will become much more important for adults, because adults will be the ones going back to school to seek additional training throughout their work lives to help them adjust to their jobs or change to new ones.

Training and education in the future must be geared toward adaptability and flexibility. People will need to be adaptable and flexible to deal with changing conditions, as technology and the labor market change. The role of education and training will be to strengthen basic education on the one hand, and to strengthen the access to and diversity of vocational training on the other hand. Both educators and citizens need to think of learning systems not simply as education and training concentrated in the younger years and basically ignored in the later years, but as a recurring, lifelong endeavor. The emphasis should shift to adult, recurrent education.

QUESTIONS AND ANSWERS

Russell Rumberger

Question: The three most successful economies in Europe—Austria, Switzerland, and Germany—all put about 70 percent of an age cohort through a vocational training program in high school that starts at age sixteen. They give very broad vocational training to the students so they have a much broader background when they come out of that three-year program than I would guess most vocational students have in this country. Certainly the students—young people in their first jobs—get more and broader training from their employers than young people get here. I do not disagree with your recommendation that vocational training be refocused more toward retraining adults, but are you saying that Germany, Switzerland, and Austria have really the wrong structure, that they need much more basic education, and that a well-reformed vocational education system in this country at the younger age levels is basically something we should give up on in vocational education?

No, I would not give up on vocational training for young people. I think it's hard to make these simplistic comparisons between our system and the European systems. If you want my own views about it, I tend to think about reforms in vocational education and education generally going together. There's been some discussion, for example, of a change in the graduation age from high school. What's important is that we make sure students or young people get a strong basic education. If they can acquire it by the tenth grade and then go on to receive vocational training, that's fine. The only thing I worry about is to the extent to which they are prevented or precluded from getting this strong basic education because of concentration in vocational education. In such cases, I think it can be detrimental in the long term.

My own impression about European educational systems is that their academic preparation prior to vocational education is much more rigorous than ours, so that their students at the tenth-grade level may actually have acquired more basic skills than our students. I don't know. I don't want to lean too hard on that generalization, but that's one impression I get.

I think that vocational training must still play a role for young people, but we have to be careful that people are not marshalled into it too early without acquiring these basic skills and without realizing that those basic skills are going to be their foundation on which they acquire specific vocational training throughout their work lives. So it's not simply preparing them to think, "Okay, now I'll go into some vocational area and that will do me." What they're really going to need is to be flexible, and that will mean strengthening that basic education and then going on to more specific vocational training. So we don't necessarily need to do away with vocational education at a young age, but rather to emphasize it for the adult years and emphasize that training in the basics comes first.

Question: It seems to me that we're caught in a crunch between all these changes taking place and the resources that we then need to train these young people, at a time when money is generally decreasing for education. Do you think it's really feasible to give up-to-date vocational training in a typical secondary school with typical facilities, or is that training going to have to shift to the industry?

Right now, I think we have a diverse setting for acquiring vocational skills. Some of it goes on in industry; some of it goes on in schools. I don't know if it would ever be possible, but what I would like to see is some comprehensive, consolidated program of vocational training. I don't think you can advocate only one setting as appropriate. I think we're always going to have several types of delivery systems out there. If I were going to advocate my type of reform, I would probably recommend establishing some kind of publicly supported training that serves all clients.

One practice I don't like that goes on now is vocational training that takes place in certain kinds of specifically designed area high schools and community colleges, so some states have quite a lot of overlap and duplication of vocational offerings. Some high school students can acquire certain vocational skills in high schools; others have to wait to acquire such skills in community colleges, depending on what exists. I would somehow try to consolidate the vocational training that goes on and let it serve all the people who need it. But I don't think it's ever going to be in only one particular setting.

So I don't know if there's really any easy answer to that question about whether specific training should all take place in industry or should all take place in training institutions outside of industry. I don't see that ever really being resolved. But I do think we could better integrate the training systems we do have and coordinate them to minimize or do away with overlap and duplication. In a coordinated system we could say, "Maybe some is required here and some is required there." We can work toward that kind of reform, but not a reform saying we'll put it all in one setting and that's it.

Question: If in fact you're right, and I think you are, that the adoption of high technology is going to lessen the skills that will be required by most workers—especially the analytical skills—then I really wonder where the incentives are going to be for the educational institutions to do the kind of training that I think you're talking about. Being concerned about the social impact and the growth of humanity won't be enough. Where are the actual incentives going to be to put those kinds of resources into that kind of training, if in fact it's not necessary for goods and services to be produced?

I think that we really do advocate strengthening education. But it isn't strengthening education only because of the needs of high technology. If high technology has a tendency to reduce skills and produce a lot of lower-level jobs, as you say, then the strict employment need for those skills is diminished. But at the same time I think the social need for those skills increases. And that's what I tried to point out. As our society becomes more complex, people will need to participate more in decisions about politics and the community and the application of technology, so in that sense I see a need for strengthening education. But I don't know if that is going to be enough incentive. There's a social need for strengthening education rather than a strict job-related need. So that's how I would answer your question.

Question: I'd like to get your views on just how you see the nature of work changing. You said that work is already changing from being more physical to more nonphysical. But you also projected it to change to less mental work because the computers are going to be doing this. What form will work take in the future?

In twenty-five words or less? Well I'll explain one scenario that I believe may be foretelling. I don't know how many of you are familiar with the book *Player Piano*, written by Kurt Vonnegut in 1952. It was his glimpse into the future. Even though it was written thirty-one years ago, I think it's just as relevant today as it ever could have been, and maybe it's going to be more relevant in the future. This is the basic idea. The inevitable tendency of technology is that it reduces the need for people to be engaged in the production of goods and services. And Vonnegut sees that as a benefit, an ultimate benefit, for mankind because it will solve our basic economic problem, which is the production of needed goods and services. Technology is going to aid us to do this more cheaply, with less labor, and perhaps more efficiently, but there's a problem. We have to decide how to distribute the benefits of these changes to the population as a whole.

Well, right now we don't do a very good job of it. We have 11 million people unemployed, with one out of every seven Americans living below the poverty level. So it's a distributional problem that really has nothing to do with the state of technological development. But the inevitable tendency is that technology is going to be able to free people from what some call the burden of work. Whether that's good or bad really depends on how we distribute the benefits of the work that's being done.

An example of a future work plan has already been set up in Japan, where a firm that manufactures robots will have all the manufacturing done by robots. The robots are going to build the other robots. And so there's basically only two or three workers involved in the production of robots and otherwise it's a completely automated factory. And the only time they need to have people there is if there's a breakdown. Whether or not you believe that's a cure for our economic problems again depends on how the benefits are distributed.

In some ways I think it really is inevitable that we're going to eliminate the need for most work in the future. Maybe that means we will all work fewer hours per day, or that people will retire early, or retire earlier than they have. But the problem we may face as a society is really how to distribute the jobs that do exist among the people who want to work, and how to distribute the income or wealth that our society produces to everyone in some equitable fashion.

That's the direction Kurt Vonnegut saw it going thirty-one years ago, and it's just not a situation with an easy solution. Technology's not going to solve any of those problems. We—as a country, as its citizens—are going to have to solve the distributional problem ourselves. To take a current example, we could eliminate unemployment tomorrow if we wanted to. It's not a technical problem. Unemployment is not inevitable. It's a social problem or political problem and it's going to be that way in the future. But if technology is going to accelerate the rate at which people are going to be pushed out of jobs, then resolving that problem is going to become even more pressing in the future.

Question: I like your way of demystifying high tech by looking at the numbers rather than the percentages. But I'm not sure I agree with your conclusion. You demystified high tech, but then you seemed to give the usual high-tech story that we need more basic education, more analytical education. Do we need it if many of the new jobs are going to be for nurse's aides and janitors? Are those the high turnover occupations?

I tried to answer that in responding to an earlier question, when I said that the impetus for reform in education—to strengthen it by improving basic skills—does not come from high technology in a strict, job-related sense. Rather the impetus for reform comes from other needs, which are to strengthen the analytical and communicative skills of people as citizens, as political participants. So that's where I see the impetus for reform coming from. It's not really related to work skills in a narrow, specific sense.

Question: You have argued that skill requirements will be reduced in the future, and I understand what you are saying. But isn't it going to be better if a person doing word processing does know how to spell and can do letter-perfect typing? Won't that person be a better worker and therefore more likely to get higher wages? And so will the need for those skills really be reduced?

I think that the skill will be reduced. Right now, the spelling corrector software for word processors queries the person about possible errors that it recognizes. But at some point it will probably become so advanced that it will not have to query the workers, so the need to type correctly may vanish. Now you could argue that people who can type well or spell correctly will be more efficient in their jobs, so maybe they should have higher rewards associated with their jobs, receive higher salaries, or the like. I think in part that's true. I'm not trying to paint a black and white picture that's all this way and not that way. You know it can be some of both. But I still think the direction is generally the same.

The impact of technology on lowering job skills *can* be mitigated in at least one way, and that is through organizational change. As you know, a lot of times jobs are defined in a pretty narrow sense. But if people are given more responsibility or broader responsibilities, then the skill requirements they need to function will probably increase, because they're going to be doing a greater variety of tasks. Maybe if people become more involved in decision making in firms and in their jobs—if we again change the organization—they may need more decision-making skills. But that will really depend on how work is organized.

Some of those kinds of changes are taking place. Work teams in production and assembly are one example. To a lesser extent, there are quality circles that are getting workers involved in decision-making processes. So communicative skills and analytical skills are again needed not in a strict, occupation-specific sense, but in the sense that workers may function in a broader array of tasks and responsibilities.

Probably the ideal work structure will involve producer cooperatives and more democratic forms of production in work, and—to the extent that people will be moved around more—they'll both have and take more responsibility for thinking about the nature of their work and how it's organized. And then, maybe, the skill levels will go up. But those changes aren't necessarily going to come about, and they haven't been coming about very quickly before, so I'm not very optimistic that they will.

Question: I agree with most of what you've said today. I have a question, though, that grows out of my own concern about educational institutions overfunding high-tech programs, getting on the bandwagon and building up lots of curricula and buying lots of equipment to train for the high-tech jobs. I recognize and believe that technology doesn't operate in and of itself, that there are other forces at play. What do you think some of those other forces are that either will accelerate or perhaps retard the rate of change? Also, what ways could educators look at those to get a

better fix on how much to spend or how soon to put in new programs—some way to prevent a potential landslide of new programs that are going to wash out in a couple of years?

I worry about that. Educators, like everybody else, react to fads and follow fads. The fad now in high tech is for every school or community college to have a program in robotics. Now you know that it's good, in a sense, because these concerns generate interest in education. So in that sense I applaud all the reports that have been coming out, because education has received a lot of attention now, a lot of it good attention. And that can be useful in building energy to help reform education and get people involved.

But you're right, the worst aspect is that we think about vocational training only in a very narrow sense. We only ask for more money to put into these kinds of programs, perhaps to the detriment of other programs, because now everybody has to be literate in computers, now every school has to offer these programs, and you know where the money ultimately comes from. It means cutting back funds for extracurricular activities, for the arts, and so forth. So I worry that educators follow these fads too quickly.

I think we all need to be cautious about jumping on the high-tech bandwagon, and that's really what my presentation had to say: It's not so clear what the implications are, it's not so clear what the trends are going to be. Educators generally are followers, in the sense that they wait for somebody else out there to give them a signal, to say this is what I need, A, B, C, high tech, robots, therefore you need to teach this or that program.

I do think there are people in education who look at the other side, who are forward-looking. They don't wait for business leaders and politicians and others to say, "Hey, you people in the educational community, I need you to do this, this, and this." But, in fact, most educators need to think more about what the long-range needs are going to be for educational services. They should be engaged in analyses and discussions about what the needs are, rather than just responding to the needs. I would even go so far as to say that they should become more involved in thinking about how education is applied in the workplace. I'm not sure how useful this advice is to most of you who are involved in education, but for me, I wouldn't want to be sitting back, letting people tell me what they need. I'd rather try to figure out what the needs are or how education can best be used.

I think there's a real problem in this country right now of underutilized skills. I think we have a very highly educated work force in the United States. The average educational level of the unemployed in the United States is over twelve years of schooling. I believe it's higher than any employed work force in the world. So we don't have a problem of a simple lack of education in our economy. In fact, a lot of people are underemployed or are in jobs where their skills are underutilized. I think part of the work that needs to be done—and educators need to be involved in doing it—is to think about how well skills can be used in work. How can we use our people's skills better? Again, I don't know whether that view is helpful to you, but it is for me. I have just embraced it as a way of thinking.

Question: If much of the job growth will be in either high-technology areas, where a few occupations will require advanced R&D understanding, or in low-technology areas, such as the service economy, do you think that this will increase social stratification very much? If so, what roles will educational curricula play in countering or supporting the increased stratification?

That's a good question. I think that technology does have a potential to increase stratification. For example, it may have the effect of eliminating more middle-level, middle-class jobs, so there may be repercussions around social mobility. That is, people may end up with lower-level jobs than their parents held because there won't be many opportunities for moving upward. If there aren't enough jobs for upward mobility, some people are inevitably going to have to move downward.

But it doesn't have to be that way. It's a social or political issue that involves deciding first of all how we might alter that distribution of jobs through such forces as reorganization in the workplace, legislation designating the kinds of jobs that may exist in our economy, or redistribution of jobs and/or income. The issue is how we shape the distribution, how we allocate people within that distribution. And of course education has always played a very important role in allocating people in the distribution that exists.

The general tendency in the United States, as in most advanced countries, is that the people with the most schooling have the best jobs. But if that distribution were altered in certain ways, that would still probably be the general case—people with the most schooling would have the jobs—but more and more people with those high levels of schooling would be pushed down into the lower-level jobs. That's where the problem is—an underutilization of skills, which I sometimes call overeducation. I know that people in education hate that word, but whatever word you want to use, the plain fact is still that people with high levels of education are still going to be shoved down. And I'm not sure what education could do to prevent it.

I guess what I would like to see happen is for citizens to gain more social awareness and more education geared toward social-political needs, because the strict educational requirements of jobs are probably going to go down unless the social-political organizational changes come about. We should increase education aimed at developing social awareness, analytical skills, and awareness of political forces and institutions. If, for example, the voter participation rate in the United States is an indication of our social awareness, then we don't have a very high level of social awareness, because usually less than half the voting age population votes. On the other hand, some countries, such as Sweden, have full employment policies and a very high participation rate in terms of political action. So if you think of the voting rates as a reflection of our social awareness in the United States, then our social awareness is pretty low. And that may be an area where education can do something.

Question: We're going to need a great number of creative ideas to deal with this problem you've just been discussing. I have an idea that's a bit creative and I would like your reaction to it. If we provide additional basic education and general and liberal education, it may still be that no one will want to work at some jobs, such as in food service, custodial service, janitorial, and so forth. Maybe we could look at our work, instead, on sort of a divided basis, each of us having two jobs. For example, a person may work half a day as a physician and the second half-day as a janitor. What would be your reaction?

That's a great idea. Again, making it work will be a distribution question and an allocation question. If there are going to be more low-level, undesirable jobs, then how do we allocate those? Maybe we all should empty our own wastebaskets, wash our own windows, do our own typing, or whatever. I think there is a lot of interest in the idea of job sharing. People *are* aware of the allocation question of how, given the amount of work that exists and the kind of work that exists, we should distribute people in those jobs. Your idea would be one way of doing it.

If you want to be practical about it, I'm not sure how society would implement it, but in an ideal state, why not? Why shouldn't everybody do some creative interesting work, and everybody do some of the low-level work? Unfortunately, I don't see that forthcoming in any sense.

Question: As a sidelight to that last question, there are plenty of physicians who are also janitors. They happen to be women who are doing housework as well as surgery. But I want to ask you about the basis of your projections. You said the U.S. Bureau of Labor Statistics projections are your major source, and I wonder if any of them take into account the enormous potential for job development in space technology? A lot of people twenty-five to thirty years ago didn't think that was worth discussion. I think that today, based on a discussion I had with an astronaut who was here last year, there is an incredible potential for expansion of jobs there, and I don't know if any of your projections take into account that kind of growth.

A general answer to that question would be, yes, they did take that into account. I can't answer specifically about that particular industry. I don't want to go into elaborate explanations about the methods that the BLS employs, but I do look at which areas of the economy are expected to expand, what the composition of jobs in that industry is expected to be, and what their projected rates of growth are. The BLS goes through quite a long process to make their projections and in general, they do account for it. But it's very difficult to account in any really accurate sense for the impact of technology. I've talked with the people at the BLS about this, and they're pretty aware of the kinds of directions in which the labor market is going. What they're not able to do as accurately as we all would like is to gauge the magnitude of those directions.

One example that they told me about is the case of telephone operators. As you probably know, there has been quite a job displacement of telephone operators in the United States because of all the automatic switching and direct-dialing equipment that is now being used. BLS people anticipated the direction of that trend when they made projections. In the latest round before the current projections—the 1970-1980 projections—they anticipated correctly the direction of that trend. But they understated the magnitude of the change, because they didn't think the displacement would occur as fast as it did. I think, in general, they are able to gauge directions pretty well, but the magnitudes are much more difficult to estimate.

So I can't answer about directions in the space industry specifically. It could be growing again. As I said, certain kinds of high-tech industries are growing, as certain kinds of high-tech occupations are growing, but that doesn't necessarily mean they're going to provide a lot of jobs.

One analysis I saw of the high-tech industries showed that certain industries—manufacturers of microcomputers, microelectronics, and things like that—accounted for almost all of the growth in manufacturing employment in the United States between 1969 and 1979. But while some of those industries are growing, others are contracting—the more traditional "sunset industries," as they're called. The net growth in employment in manufacturing was really quite small. So even if some particular high-tech manufacturing industries do grow, percentage-wise they don't employ a lot of people, and there are other areas of industry that are going down.

I expect that the general trend we have observed in this country in the last twenty or thirty years will continue, which is that manufacturing will become a less important employer in the United States, and the services area will become a more important employer. But even within these broad sectors, there's a lot of movement, with some growth and some decline.

Question: I've just returned from Japan, where I visited a major Japanese steel industry that is reputed to be at the pinnacle of high tech in the steel industry. We are in the process of converting six Ohio steel plants to the same technology. I didn't see anything in the Japanese plant that was overly sophisticated. Mostly, I saw the use of statistical processes and controls, and I saw a lot of good use of the equipment they have. My concern is, if you say America is reducing the need for its basic industries, then we're investing a lot of money in the belief that basic industry may be an important source of employment and that what will make the big difference is whether we're going to do the job much better now.

What I noticed in Japan that I think was most prominent was that, overall, the Japanese steel industry was no different than our steel industry. But they don't put a lot of emphasis into vocational education until people get out of school and start work with the company. Does that mean we should go back to where it takes twelve years to go through the academic curriculum? If it does, how are we going to keep kids in school?

Do you mean using vocational education to keep kids in school who otherwise might not stick through an academic curriculum? I don't have a simple answer for that. I think one of the answers may fall out of our efforts to strengthen education below the last three years of high school. Maybe as we raise standards and reform education in the initial grades, students will acquire more basic skills before they get to the higher grades.

I've done some analyses of dropouts. I know that one of the best predictors of dropout behavior is a student's inability to function at the earlier grades and deal with academic environments. To the extent that we can improve and provide compensatory education to students who need it, we may in fact help them survive through more years of academic curriculum in the high school.

When I talk about strengthening basic education, I don't necessarily mean it would all take place in the high school and that, as a result, we'd push vocational education out. If we could improve and strengthen basic education up to, perhaps, the tenth grade, then we may have accomplished the goal by that grade. I think we need to think about reforms in education very broadly, and that's why there have been these proposals to reduce the high school graduation age to seventeen. There's a proposal in New York to do that. A Carnegie Commission looked into the area of youth and reforms and talked about ending high school at age sixteen—at the tenth grade.

We know that the distinction between high school and postsecondary education in some ways is artificial. There is no need for high school to end at twelve years and college to start at thirteen years of schooling. My own idea would be to have a system where high school—whatever we mean by high school—would end at the tenth grade, and then people could go on to college—if you want to call it that. (In some places they call it upper secondary.) But then our students could go on to more advanced academic coursework or vocational coursework or whatever.

There's nothing magic about twelve years of schooling, and nothing magic about eighteen being the age at which you should be able to choose to go to college or not. I think that for some people we should lower the age of that choice now. I think that's part of the problem with dropouts. If we give kids more choice at those ages, they may be able to deal with some of the problems they face more effectively. Those choices could include going to a vocational program in what we now call the eleventh grade, or going to work, or going back to (academic) school.

This would also fit in with the idea of recurrent education, because people would not be compelled to get other education and training before they entered the job market anymore.

I think some of those trends are evident already today. What we now call "stopping out of college" is what we used to call "dropping out of college," and it is much more acceptable and prevalent today than it was ten or fifteen years ago. People are going back to school as adults more than they did before. I recently saw the enrollment statistics for postsecondary institutions, and now one out of every two college students is over the age of twenty-five. So these changes are already taking place, and I think they'll evolve more in the future.

Question: If the picture you paint is that high technology is going to result in the deskilling of many jobs in our labor market and that vocational education's role or responsibility is to train people for jobs, then what do you think vocational education's role ought to be in responding to this deskilling of jobs? What should vocational education be doing, if anything, to provide training—I hate to use the word education—for the large number of jobs with low skills—the janitors, the waitresses, the cashiers?

In some ways, vocational education may not have that much of a role to play. But I think in the broadest sense it's going to have a *more* important role to play. I can't say with any certainty, of course, but even if the skills are lowered for a lot of jobs—which I think is going to happen—technology will still create the need for new skills, and people are going to have to acquire new skills much more often. So we may end up using a scheme that has been instituted already in Europe, which is to send people back to school again and again, with the general sense of school as being any kind of training. People would be going back to school more often, so that the actual amount of time or the amount of effort we would be devoting at any one time to providing vocational training or education would increase, even if the effect of high tech is to lower the skills. We're going to have more people in the educational system or training at any one time because more adults are going to be coming. One example of how this is done in Europe is what they call paid educational leave. But theirs is a much more integrative system.

One way to help combat our unemployment problem in the future would be to get our citizens to think about education and work as going on simultaneously throughout everybody's lives, so that you just don't go to school for twelve years or longer when you're young and then go to work for forty or fifty years when you're old. You would, in fact, have an initial stint of education and then you would combine or alternate education, work, and leisure throughout your life. In some countries, West Germany being one example, the program isn't that large yet, but the idea is that at any one time you're always going to be channeling people out of the work force back into education and training and then channeling some people back into work. This helps reduce the amount of people available to work, because at any one time there will always be a part of the adult population involved in education and training.

I think that the general trend will be to increase the role of vocational types of training, even if this general skill reduction is going on.

Question: I've heard a lot of talk in various sectors about the need to strengthen basic education as you have addressed it here today. We know, in reality, that most of the jobs that have been projected for the future will require mainly very low skills. My question is, if education strengthens basic education, what do we do to prepare the private sector for the workers we are going to train to be analytically astute, but who

will go to those low-level jobs? Have you given any thought to designing a model for industry to get ready for these workers, so we won't have disgruntled employees?

I don't think I'm in a position to design a model. I think some employers are really quite aware of this. There are some employers who are becoming much more aware of the need to integrate workers and work in a more flexible fashion and to change the organization of work. As workers' education levels increase, their demands are going to increase as well, so in some ways employers may be forced to deal with what those needs are. Workers may also be better able to articulate those needs to their employers and get involved in the reorganization of their work.

I try to be an optimist about these changes because I think there are examples of them happening. Some progressive companies are known to be organized in that way. Hewlett-Packard is an example. I've often heard people who work there say that the management has taken a very progressive attitude. In essence, the company realizes that since it has better-educated workers than it ever had before, they're not going to be satisfied with narrowly defined, repetitive tasks. So it's in the company's own long-range interest to involve its workers more in decision making, because it will improve the long-term stability and productivity of the company.

I don't know how much that is happening elsewhere, but I like to believe it will happen more. And I can't model it. I think it's a reactive process. I think employers are in a position of having to react to the employees they have coming into the companies, and I think there are examples of employers reacting in constructive ways. Naturally, not all employers are doing this.

Question: I have a two-part question. First, you've talked about underemployment, high tech, and so on, and you've mentioned that employers will need to respond in certain ways. Would you comment on what the future effects might be on labor unions and management relationships, in light of this advancing technology and full employment? Second, what is your view about compulsory national service for young children or youth—giving consideration to employment, the advances of technology, and so on—in parceling out this work?

I think there's a role for unions to play in this. I'm wearing my idealistic hat, but I think the real answer to many of these problems we're going to face or we are facing now is much more cooperation and involvement by all parties concerned. I don't know enough about unions to characterize them in any general fashion, but many people have characterized labor relations in the United States as being very adversarial when compared to other countries, where employers recognize the need for unions and workers to have a voice, and unions recognize the need for employers to be involved in those decisions. In Europe, in particular, there's a much more cooperative attitude toward the role of unions at not only a company level, but also at a national level.

I can't predict what direction labor-management relations will go in this country, but resolving some of our pressing social problems in the future will mean developing much more cooperative relations and getting much more of the rank and file involved—both workers and citizens. It won't be just a question of leaders talking to leaders and union leaders saying we're going to do this and company leaders saying that workers will do that. Workers at all levels and citizens in general will have to get more involved in making those kinds of decisions about work and society. That's the kind of thing my coauthors and I talk about in our book, *A New Social Contract*. Social decision making and participation will have to start at the bottom and go up, not the other way around.

In answer to your second question, I think national service is fine. I think it has potential to solve some of the nation's unemployment problems, youth unemployment in particular. But I see a more active role for the public sector in a broad way, not just for youth and public service employment, but also for public sector involvement in the economy through providing more jobs, employing more people, and finding useful ways for more people to be productive.

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